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1 13. Riparian Restoration and Management – [Moderate]

1.1 Introduction

1.1.1 Description of Technique

The riparian zone is defined as the area adjacent to flowing water (e.g., rivers, perennial or intermittent streams, seeps, and springs) characterized by moist soils and plants that require moist conditions (Knutson and Neaf 1997). Positioned in the lowest topographic portion of the landscape, riparian areas contain elements of both aquatic and terrestrial ecosystems that mutually influence each other and occur as transitions between aquatic and upland habitats. As such, they provide a rich and vital resource to Washington's fish and wildlife. It is estimated that, since the arrival of settlers in the early 1800s, 50% to 90% of riparian habitat in Washington has been lost or extensively modified (Knutson and Neaf 1997). This technique describes the restoration and development of native riparian plant communities on streambanks and floodplains.

Riparian plant communities have been directly impacted by urban development, agriculture, livestock grazing, logging, mining, and recreation. And they have been indirectly impacted by activities that have altered site hydrology such as urbanization, deforestation, stream channelization, drainage ditch construction, groundwater pumping, and surface water diversion, withdrawal, and impoundment. In response to these impacts, specific techniques used to re-establish plant cover may be passive approaches limited to changing the land use or management of an area so that native species begin to re-establish on their own (Kauffman et al. 200x). Alternatively, a site may be so degraded, or the desired timeline for riparian restoration so short that passive management approaches in combination with active restoration of the soil surface and supplemental plantings are required. At sites where altered stream hydrology or channel changes have isolated the stream from its floodplain or created unstable channel conditions, restoration may require channel modification, levee modification or removal, or water management modification to reestablish bank and floodplain vegetation (see Channel Modification, Levee Modification, and Water Management techniques). Regardless of the specific technique used, when attempting to restore or improve the extent and diversity of native riparian plant species it is essential to identify and treat the cause of the degradation or restoration efforts may fail.

Natural riparian areas not exposed to obvious land use impacts may also exist in a state well below their full vegetative potential due to invasion of noxious weeds. Noxious weeds are highly invasive non-native plants that have been introduced to Washington through human activities. Due to their aggressive growth patterns and a lack of natural enemies, they spread rapidly into native plant communities (Leigh 1997). One of the most common noxious riparian weeds that elicit treatment in Washington riparian areas is reed canary grass (*Phalaris arundinacea*). Other common western Washington riparian weed species include Himalayan blackberry (*Rubus discolor*), Japanese knotweed (*Polygonum cuspidatum*), and English ivy (*Hedera helix*). With the exception of English ivy which grows in shaded wooded areas, all the above-mentioned plants thrive in open sunny sites. These species tend to shade out and displace native shrubs and groundcover and prevent the establishment of tree seedlings, often forming monocultures (Leigh 1997). In addition to impacting the extent and diversity of native plants, reed canary grass can invade low-gradient, low velocity, shallow streams encouraging sediment deposition and consuming dissolved oxygen as they decay [Need reference for this]. Where noxious weeds are present, riparian restoration involves using the best available scientific information to assess the potential for improvement and identify what, if any, specific restoration techniques may be applied. A variety of techniques have been used to control noxious weeds including shading, mowing, herbicides, flooding, burning, and physical removal (Tu et. al 2001).

Physical and Biological Effects

Successful implementation of riparian restoration and management can, over time, result in significant improvements in the cover and diversity of desirable native riparian plant communities. Because of the tremendous variation among sites it is difficult to predict a plant community's response to changes in management, but in most cases changes will take many years to fully realize.

Restoration of riparian zones has a wide range of positive effects on bank stability, fish and wildlife habitat, water quality and aesthetics. Increases in the rooting density and above-ground stem density can stabilize streambanks by physically reinforcing the soils and buffering the erosional forces on the surface of flood prone areas. A biologically diverse and vegetated streambank/floodplain surface provides a number of fish and wildlife habitat benefits including input of detritus and invertebrate food sources, near bank cover, and high-flow refuge (Knutson and Neaf 1997). Well-vegetated banks may also improve water quality by reducing water temperature which in turn raises its dissolved oxygen content, retaining incoming sediments and pollutants, and increasing the uptake, storage and release of nutrients into the aquatic environment. Vegetated floodplains also serve to reduce flood flow velocities, reducing scour and encouraging floodplain sediment deposition. They moderate stream volumes by reducing peak flows through reduced surface runoff and by storing and slowly releasing water into streams during low flows (Knutson and Neaf 1997). Finally, as woody plants mature, the potential sources for large woody debris recruitment to the aquatic zone is increased. Knutson and Naef 1997 note many fish and wildlife benefits associated with riparian zones and provide additional reference information.

Successful removal of large areas of noxious weeds may temporarily decrease the bank and floodplain soil stability due to reduced vegetative cover, and may reduce wildlife cover and food sources until new vegetation is established. Specific impacts of noxious weed removal varies with the technique employed. For instance, improper application of herbicide for weed control can kill adjacent plant communities and harm aquatic life within and downstream of its area of application.
Successful in-stream reed canary grass removal may increase channel conveyance of water, sediment, and woody material and allow a diverse channel bedform to develop. However, if the removal of in-stream reed canary grass is accomplished through dredging, the physical and biological effects expand

to include direct destruction of in-stream habitat and aquatic life within the area of application. It may also alter the cross-section and profile of the stream causing channel degradation or aggradation, and isolating the stream from its floodplain, which in turn impacts plants and wildlife within the floodplain. These effects may extend up- and down-stream of the dredged area.

1.1.2 Application of Technique

Improving riparian condition through land management changes alone is most appropriate on sites where land uses such as poor livestock management, recreational foot traffic, logging, or mowing have degraded but not entirely eliminated desired vegetation types and soil structure. On such sites, improvements in land management may be sufficient, simple, and successful. Sites affected by more severe land uses and characterized by sparse or weedy vegetation and disturbed soils, may require active management such as soil scarification or amendment, noxious weed control, channel modification, supplemental planting, plant maintenance or silvicultural treatments. This approach should be avoided where short or long-term land use or management activities are not compatible with establishment and growth of the desired riparian vegetation. If the channel is unstable, the cause of channel instability will need to be assessed and addressed prior to riparian restoration. Otherwise, it is probable that new plantings will be lost due to bank erosion or changes in the level of the water table.

Establishment and recovery of native riparian plants will be faster in sunny, low elevation, or moist sites compared to shady, higher elevation, or arid sites. However, such growing conditions can also trigger rapid establishment of weedy or non-desirable aggressive species, so weed establishment patterns at projects sites should be well understood before implementation of any treatments. No matter what the weed or weed removal/control strategy employed, noxious weed removal effects are likely to be short term if not combined with revegetation efforts and continued noxious weed control until desirable riparian vegetation is firmly established. Both short and long-term maintenance of riparian restoration sites should be linked to the dominant physical and biological factors affecting growth of both desirable and un-desirable plant species.

Use of riparian management techniques should consider the land use setting, specifically if the site is in an urban, agricultural or wildland environment. Some riparian management treatments may be appropriate in one type of setting and not in another. For example, the allowable height or species of vegetation may be limited due to its proximity to utilities, to address safety concerns, or to preserve views.

When placing plant materials, fences, offsite watering facilities, plant irrigation systems, and other materials in the riparian zone, the designer must consider the effects of flood flows such as deposition of sediments and debris, as well as scour, or locate these facilities outside the floodprone area.

Scale

Riparian restoration and management efforts may be undertaken on sites ranging from narrow stream fringes characterized by a sharp transition to upland habitat to larger rivers with wide riparian corridors and a gradual transition to adjacent uplands. Similarly, this technique can be implemented on small sites with limited budgets as well as long, continuous stream reaches. Clearly, the habitat benefits of this technique are much greater when used along continuous lengths and complete floodplain widths of a degraded stream corridor rather than isolated segments. On small headwater streams with narrow floodplains treating the bank may essentially include the floodplain, but as stream width and floodplain width increase treating only the streambank leaves larger areas of floodplain unimproved.

Ultimately, the treated area of a project may be dictated by project budget or property boundaries, but in cases where these limitations are less of an issue decisions on the aerial extent of project may be required. When evaluating potential treatment areas on a project site, the first priority of most riparian management projects should be to restore streambank vegetation because of its ability to provide shade, overhanging cover and detritus directly to the aquatic zone. However, whenever possible we encourage practitioners and project managers to treat adjacent floodplain areas further from the active streambank. As the width and extent of vegetated corridors increase, so do the improvements in bank stability, sediment and pollutant detention, wildlife habitat, and detritus input into aquatic systems.

1.2 Risk and Uncertainty

Riparian areas support highly adaptive vegetation that can rapidly establish under the proper land use and site conditions. However failure to identify the numerous biological and physical site factors that limit riparian plant communities can hamper success of riparian restoration.

Biological risks that can limit establishment or recovery of native plants include noxious weed invasion, small and large mammal browsing, trampling, or rubbing (including livestock, deer, elk, voles, mountain beaver, and beaver) ungulate browsing, beavers, and plant disease infestations. Biological risks associated with reed canary grass control include the effect of herbicide control on non-target species and the risk of re-establishment of reed canary in treated sites. Physical factors that can limit plant growth include drought, low water table, excessive or unanticipated inundation regimes, sediment and related flood flow deposition, scour and erosion, and overly compacted, shallow, or disturbed soils, vandalism, and mowing.

Riparian management efforts have little risk to infrastructure or to geomorphic process. One potential effect, especially if undertaken on a large scale is reduced conveyance of flood flows. The risks associated with noxious weed control vary with the technique employed. Dredging and herbicide use pose a direct and indirect threat to non-target species of plants and aquatic life.

1.3 Data Collection and Assessment

Implementation of management-related techniques require two primary considerations: 1) identification of the source of riparian degradation and 2) accurate assessment of the vegetative site potential and capability. These are described in more detail below.

1.3.1 Identify Cause of Riparian Degradation

This technique is implemented to develop or restore plant cover and diversity on streambanks and floodplains. Therefore it is essential that the cause of the riparian degradation be identified and addressed. Frequently, the causes of riparian degradation are related to an existing or historic land use such as livestock grazing, logging, or heavy foot traffic. Changes in management can be stand-alone treatments or part of a larger treatment that includes supplemental planting, and/or channel and levee modifications. Failure to identify the source of the degradation may limit project success.

1.3.2 Determine Vegetative Site Potential and Capability

An important factor in determining the specific riparian management technique employed is determining the vegetative site potential and capability (see Washington including Crawford 2001). Vegetative site potential is defined as the highest ecological status a riparian area can attain, and is often referred to as the "potential natural community" (Prichard 1993). Vegetative site capability is the highest ecological status a riparian area can attain given political, social, or economical constraints (Prichard 1993). Evaluation of vegetative site potential and capability incorporates a variety of physical and biological site conditions such as hydrologic regime, groundwater depths, soil type and characteristics, climate, elevation, site topography, existing and historic vegetation, fish and wildlife on site, and biological and physical site constraints (see Planting and Erosion Control Appendix for more details on specific factors to consider). These site-specific characteristics and the site capability determine the plant communities that can be expected at a site under a specified land use. With caution, locating reference sites in the same or nearby stream reach or watershed may assist determination of site potential and capability.

If noxious weeds are on site, additional factors to consider include species present, the density and extent of the stand, growth habit of the weed, quality of habitat affected, likelihood of success of the control method, and the extent of adjacent noxious weed seed source (Tu et. al. 2001).

Methods and Design

The design methods for riparian restoration treatments depend on the scope of work anticipated and the specific technique selected. Restoration may be limited to changes in land use or management, or it may include supplemental planting. Particularly degraded sites may require extensive site preparation and short- and long-term maintenance. Channel modification, levee modification or removal, and water management may also be required to address human induced changes in channel stability, floodplain connectivity, and water availability. One common element to any riparian restoration technique is a thorough understanding of natural riparian plant processes. This includes riparian plant colonization patterns, impacts of flood flow, inundation, and the associated drop in water table. All techniques should consider the minimum required width and extent of a vegetated riparian zone to meet objectives. Important details related to specific riparian restoration techniques are discussed below.

1.3.3 Changes in Land Use or Management

Changes in land use or management are considered passive approach to restoration (Kauffman et al.

200x) and may include cessation or modification of current on-site activities that limit the species, diversity and extent or riparian vegetation. Such activities may include but are not limited to livestock grazing, timber harvest, mining, agriculture, periodic mowing, development, or any activity that modifies the natural hydrology of the site. Modifying these activities may require local, state, and/or federal purchase or lease of the land (see Land Preservation and Buyback) or water rights, regulation development and enforcement, watershed planning, or simply a documented commitment by the landowner. Any and all changes in land use and management for the purpose of riparian restoration should have a long-term commitment to be effective. This commitment should extend to fence maintenance and repair when applicable. Be sure that those responsible for on-site maintenance are aware of the commitment and the location of all new plantings. There have been numerous examples of park, golf course, utility company, and other maintenance crews mowing down new plantings because they were unaware of their existence or intension.

If relying on land use and management change as a stand-alone treatment (i.e., without supplemental planting), consider the likelihood and establishment time for natural regeneration of desirable vegetation on site. As described in Briggs (1996), factors that affect the natural distribution and propagation of riparian plant species include:

- Spatial and temporal variation in the "seed bank" Is there a natural source of seeds of the desired plant species available to the site? This may be a difficult question to answer. Factors influencing seed availability include proximity and abundance of species to the site, abundance and characteristics of seeds produced by the species, and dominant seed dispersal mechanisms (e.g., animals, wind, water). Note that vegetative reproduction (sprouting from stems, lateral roots, or trunk bases) is also a common form of regeneration for many riparian plant species.
- Variation in scour and deposition (Gecy and Wilson 1990). These affect the stability of seeds and plants during germination and establishment, and the distribution of water-borne seeds.
- Inundation depth, frequency, and dispersion. Many plant species are adapted to, and depend on, flooding for propagation. Flood disturbance can revitalize riparian ecosystems by producing sunny, bare soil sites that lack competition from other plants and have high moisture availability. Such sites are ideal for the establishment of colonizing vegetation such as red alder, black cottonwood, and willow species.
- Elevation (Ericsson and Schimpf 1986; Szaro 1990), drainage area, geology, and flow regime (Zimmerman 1969). These effect seed availability and dispersion.
- Characteristics vital to species' germination and growth (e.g., water availability, soil condition, physical and biological constraints)

1.3.3.1 Grazing

A number of grazing management tools exist to help control livestock use of riparian areas, including fencing and establishment of special use riparian pastures, pasture rest, variation of stocking rates, locating stock trails away from riparian areas, constant herding, salting, and innovative distribution control practices (Knutson and Naef 1997). Keep in mind, that if livestock are being removed from the riparian zone and stream, such changes in grazing management may necessitate development of alternate water and shade sources. Local Washington offices of USDA Natural Resources Conservation Service (NRCS) and Bureau of Land Management (BLM) are excellent sources for information on specific grazing management techniques. A practical reference for grazing issues available online is Adams et al. (1998).

1.3.3.2 Timber Harvest

Past timber harvest practices have severely reduced the ecological health and function of many Washington riparian forest due to direct removal of overstory canopy. Examples of the many impacts of over harvest include reduced input of large woody debris (especially conifers) into streams, reduction in stream shading, and substantial losses in forest structural habitat diversity (Kauffman et al. 200x). Under the 1999 Salmon Recovery Act the state of Washington has begun to enforce forested buffer widths for eastern and western Washington that restrict the harvest of trees in riparian areas (see www.wa.gov/dnr/sflo).

Techniques to initiate restoration of historically over-harvested riparian areas depend on site conditions related, but not limited to climate, existing soil conditions and vegetative cover types. For example recently disturbed dry sites with compacted soils and sparse vegetation require extensive site preparation before planting. Moist sites with dense cover of deciduous species may benefit from silvicultural techniques such as planting conifers or removing overstory or understory vegetation to accelerate growth of conifers Roni et al. 2002). But in general, treatments should follow guidelines discussed under the planting section, and be based on a solid understanding in riparian process, forest ecology and silviculture.

1.3.4 Planting

Successful planting efforts must be undertaken with sufficient planning, site evaluation, monitoring, and maintenance to ensure that long-term goals are met. Riparian areas are dynamic and challenging environments in which to undertake revegetation efforts. As detailed in the Planting and Erosion Control Appendix, plant materials must be carefully selected with regard to site conditions and constraints. In a 2001 study conducted by WDFW on ten channelized stream restoration projects in western Washington (Saldi-Caromile et al. 2001), the most common cause of plant mortality was poor plant species selection and distribution. Species appear to have been selected and planted with insufficient consideration for site conditions. Other possible causes of plant mortality observed in the study included inadequate site preparation and/or maintenance, inadequate protection from animal damage, poor plant stock quality, planting by under-trained crews at inappropriate times of the year, vandalism, and disease. Some of these causes are difficult or impossible to control, but most are easily controlled or minimized with adequate a bit of planning. To the extent possible, high densities of deep-rooted plant materials should used, and installed at well-prepared sites. Efforts should be made to protect any installed plants from browse, trampling, and plant competition. Consider too, that in some cases, the most aggressive plantings might be out-competed by either desirable or undesirable riparian plant species.

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There is often a trade-off in both cost and effort between aggressive site preparation and required site maintenance. For instance, the required maintenance at a site dominated by dense thickets of noxious weeds may be lower if aggressive site preparation techniques are employed. Such site preparation techniques include mowing, grubbing out the plant roots, plowing the soil, and/or applying herbicide to the weeds at the appropriate times of year. On upper floodplain sites that have a low probability of flooding (and subsequent soil erosion) the application of a biodegradable weed barrier covered with a thick layer of mulch can suppress weed growth and retain soil moisture. Alternatively, weeds may be removed around the immediate vicinity of the new plant and frequent mowing will be required around each plant to minimize plant competition for water and light. The decision of which technique to employ should consider the long- and short-term availability of funds and work crews.

When developing a planting plan, consider the necessary site preparation and short- and long- term maintenance, as well as the equipment required. If a site will require aggressive site preparation and/or frequent mowing to control the growth of undesirable vegetation, and funding is limited, it may be more cost effective to plant dense clusters of vegetation, employing aggressive site preparation techniques within each cluster, rather than uniformly distributing vegetation throughout the site. This will reduce the preparation and planting area and allow the use of a mower or tractor between clusters rather than requiring use of a weed-whacker throughout the entire site. These planted areas can then be expanded as more funding becomes available.

Explain how mulch helps to suppress weed growth, conserve moisture in the soil…)

Site preparation techniques that can make a site more amenable to naturally colonized and planted riparian vegetation establishment are discussed in more detail in the Planting and Erosion Control Appendix.

1.3.5 Noxious Weed Control

Riparian areas dominated by invasive species are often targets for restoration. However, before implementing weed control efforts a thorough understanding of the following consideration are recommended:

- Biology of the targeted species;
- Short- and long-term limitations of control efforts;
- Risk to non-target species; and
- Realistic long-term maintenance costs.

Published case studies and research describe the challenges associated with controlling invasive species with herbicide control, shading, physical removal, mowing, and biological control. Some of these techniques will be required to prepare the site, prior to planting; others will be required as part of a short- and long-term maintenance plan. Consult your state and local noxious weed control board, conservation district, and/or Washington State University Cooperative Extension office for specific information and recommendations to control common noxious weeds found in Washington. Literary references include Leigh (1997), Tu et. al. (2001) and are available online (websites are provided in references). No matter what the weed or weed removal/control strategy employed, noxious weed removal efforts are likely to be short-term if not combined with revegetation efforts to crowd out and/or shade out the weeds, as well as continued noxious weed control until new desirable riparian vegetation is firmly established.

One experimental method of reed canary grass control that may not be found in references is the creation of artificial hummocks or planting mounds in the surrounding riparian zone. Various versions of this concept have been employed in western Washington. One version, employed by the Skagit Fisheries Enhancement Group and the Jefferson County Conservation District, consists of creating mounds of earth 2 to 5 feet tall of various size and shape throughout the riparian zone and planting them with native vegetation. Another version used by King County installed untreated wooden planks vertically into the ground form a round planter 2 to 3 feet above the surrounding soil. The planter was then filled with soil and planted with Sitka spruce, which was abundant on natural hummocks in the adjacent wetland. These hummocks/mounds create relatively dry microhabitats that may offer vegetation planted on them a competitive advantage over the surrounding stands of reed canary grass. Preliminary monitoring data for the earthen mounds found that plant survival was higher and reed canary grass was less dense on the mounds versus off the mounds (Saldi-Caromile et al. 2001). Further study is necessary to determine the long-term effectiveness of this technique and the hydrologic and hydraulic impact of the mounds.

1.4 Project Implementation

1.4.1 Permitting

Any construction activities in wetlands associated with placement of fill (e.g, creation of hummocks in a reed canary grass stand) or in-stream work may be subject to federal and state permitting. Permitting is discussed in Chapter 4.6. Herbicide application may also require the use of licensed applicators. The type of herbicide employed around water is also restricted.

1.4.2 Construction

Construction along streambanks and on floodplains often requires limiting the impacts of heavy equipment on wet sites and the minimizing the risk of exposing heavy equipment to flood events. It is therefore important to carefully select access routes, project timing, and the types of equipment used.

1.4.3 Costs

Typically revegetation efforts are given a low priority in many aquatic resource projects because they are unfairly perceived as expensive. Often the costs of management activities that degrade riparian plant communities are quite high, and the cost of restoring plant communities is low in comparison.

In addition, planting costs depend on the scale of the effort, required site preparation, and whether long-term maintenance costs are considered. In some cases plant costs are cheaper in the long-term if extra money is spent initially to purchase larger plant materials, install browse protection or implement an irrigation plan. Another cost saving planting technique relates to favoring the use of heavy equipment to create deep trenches for planting high density clumps of willows rather than spreading more labor intensive hand-planted individual cuttings uniformly over a broad area.

Some approximate costs for installed woody plant material types are as follows: 3 feet long willow cuttings - $2 per plant; 6 inch diameter willow post - $25; 10 cubic inch shrub tubeling - $2; 1-gallon containerized shrub - $8; locally salvaged willow clump - $25; 2 foot bare-root shrub - $1; and, 1.5 inch caliper ball and burlap tree - $100. Costs for installation depend on equipment costs, site conditions and the scale of job.

Approximate installed costs for fencing (according to NRCS sources) are: $0.90 LF for 3-5 barb wire fencing in rangeland applications; $1.25 LF for woven wire rangeland fence; $1.15 for 3-5 barb riparian area fencing ; and $0.50 for electric fence on fiber posts.

Alternative water source development costs vary significantly depending on method. Examples of approximate installed costs (provided by a local NRCS office), include: 2 ft deep fiber tanks - $1.10 gallon; 750 gallon 8 troughs - $800; pipelines from spring to tank including 1" diameter pipe, backhoe-dug trench, valves, and fittings - $2.50 LF.

Noxious weed control costs in riparian areas are difficult to estimate and depend on method of application. Agricultural land can be broadcast for as little as $10/acre, but costs are far higher in natural areas with varied canopy requiring spot application or hand broadcast techniques. In such cases, the primary cost is the labor, and herbicide costs are relatively minimal.

1.4.4 Monitoring and Tracking

The objectives of a monitoring plan should be clearly specified, consistent with project goals, and linked to project maintenance. Often descriptive monitoring data is sufficient to evaluate project success, identify problem areas, compare effectiveness of different treatments and provide guidance for subsequent maintenance. Photo points are a very inexpensive, simple, and useful technique for monitoring riparian zone recovery (Governor's Watershed Enhancement Board, 1993). However, depending on the monitoring objective, quantitative data may be required. If so, care should be taken to determine the minimum sample size necessary to draw statistically valid conclusions. Following are additional recommendations.

- Monitoring of plantings is sometimes complicated by the fact that installed plants may be obscured by naturally colonizing plants. If this is expected, it may be beneficial for success criteria to be achieved with a combination of installed *and* naturally colonizing vegetation, rather than simply requiring survival of a minimum percentage of installed plants.

- Installed plants may be obscured flood debris, up-rooted and removed by flood events, or damaged by beaver, voles, deer, elk, or livestock.
- If experimental techniques are used to control noxious weeds, a sufficient portion of a budget should be set aside for monitoring, and quantitative monitoring may be justified. On sites where any herbicide application treatments are applied, the monitoring area should include adjacent areas within "drift range" of herbicide application.
- Monitoring for the effectiveness of land use changes such as changes in grazing strategy, complete cattle exclosure, or changes in mowing frequency along an urban stream corridor may consist of seasonal site visits summarized in photo points and a brief memo.
- All monitoring activities should identify threats to project success.
- Monitoring frequency is site dependent, and may range from once a year to several times during the first one or two growing seasons. In some cases more intensive annual monitoring events may be supplemented by more frequent and qualitative site visits.
- For specific details on vegetation monitoring, including monitoring methods, monitoring frequency refer to the Monitoring Appendix and Elzinga et al. (1998).

All monitoring efforts should be undertaken with the broad view that true success of riparian restoration projects may require a time frame much greater than project budget and project management scenarios allow (Kauffman et al. 200x). For example, some vegetative restoration components such as herbaceous groundcover may establish or recover in a few years or less. Other components such as development of woody canopy can require decades or centuries for a full recovery. While decades of project tracking is beyond the scope of most projects, it is important for restoration practitioners to keep this long-term view in mind. More realistically, funded project monitoring seldom extends beyond 3-5 years. Such a time frame is often sufficient for monitoring of installed plants or monitoring of changes in management intended to encourage development of riparian vegetation are critical during the first few critical years of establishment, when newly installed plant materials are particularly vulnerable numerous physical and biological site factors.

1.4.5 Contracting Considerations

Relative to many other habitat enhancement techniques, of riparian management techniques can be well suited to volunteer work crews. If well supervised and trained, volunteer work crews can be a cost-effective means to install fences or plants, and monitor recovery, changes in land use, or response to flood events on a modest scale. However, on larger jobs the efficiency and expertise experience of a contracted work crew is generally more cost effective and easier to manage than a volunteer crew. Contracts with paid work crews should allow for some "fit-in-field" adjustment. This applies especially to planting efforts so that adaptive management can respond to unanticipated field conditions such as unexpected soil types, higher flows than expected, changes in plant material availability, or slower construction/installation rates. Revegetation efforts may benefit from installation in phases, or over several planting seasons so that plant species are installed in proper microsites.

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1.5 Operations and Maintenance

Successful riparian restoration may depend on commitment to sufficient maintenance. This should be a budgeted item that is linked to the maintenance plan. The level of maintenance required varies from site to site, and at many sites can be quite low, especially after improvements in land use are made, or a resilient vegetative cover has been established. Maintenance needs may be high under the following conditions: newly implemented projects exposed to large flood events, and sites prone to noxious weed invasion, heavy beaver or ungulate use, drought, and high sediment deposition. Following are some maintenance considerations:

- Irrigation. Any shallow rooted plants not rooted in or near the water table should be irrigated during the first growing season, especially in arid project sites. Irrigation of native plants should consist of infrequent high volume events that penetrate deep into the soil profile to encourage deep rooting. Frequent small watering events promote shallow rooting (Reference).
- Browse Protection. Foliar repellents (such as DeerAway™), bud caps, mesh tubing or stem screens (http://www.for.gov.bc.ca/hfp/forsite/progress/may1997/mammal~1.htm#one) may protect highly browsed species such as dogwood and willow from large mammal browse damage. In some cases of heavy ungulate use fencing may be the only option. However, consider that all these methods may be less effective in floodprone areas subject inundation and hydraulic forces of flowing water.
- Small Mammal Damage. Site observation suggests vegetation, especially smaller plants installed in open meadows (but not canopied sites) is very susceptible to vole damage. (Saldi-Caromile et al. 2001).
- Plant replacement. Replanting of dead plants may be important, but not if the cause of the stress has not been eliminated or if naturally colonizing plants are meeting monitoring objectives.
- Weed Suppression: Weed suppression may be needed, but weed control should focus on controlling or eradicating long-lived, perennial weeds that are likely to degrade the site or violate state/county regulations.

1.6 Examples

1.7 References

For more specific details on revegetation refer to SHRG Appendix 8 and ISPG Techniques: Woody Plantings, Herbaceous Cover, and Buffer Management. [this reference should be made within text.]

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1.8 Photo and Drawing File Names

Note. This section does not seem a good fit for drawings, as there are so many potential treatment types, and most not suited for figures.